

THE COMMON FROG*
VIII.

THE skeleton of the ankle as developed in the frog's class presents us with some characters, which, more than even those of the wrist, suggest the passage of the line of affinity directly from Batrachians to mammals, leaving both reptiles and birds on one side.



FIG. 51.

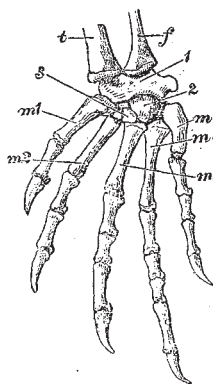


FIG. 52.

FIG. 51.—Right foot of Emeu. *a*, astragalus; *d₂—d₄*, second, third, and fourth digits; *m*, metatarsals ankylosed together except at their distal ends; *t*, tibia; *t₂*, distal tarsal element.
FIG. 52.—Left foot of a Monitor Lizard (*Varanus*). *f*, fibula; *m₁—m₅*, the five metatarsals, *m₁* being that of the hallux; *t*, tibia; *a*, astragalus; *2*, cuboides; *3*, ecto-cuneiforme.

In the first place we meet in the frog with certain extra ossicles in the inner side of the foot, which present the appearance of a broad rudiment of an extra digit on the inner side of the great toe. Now we find a structure very

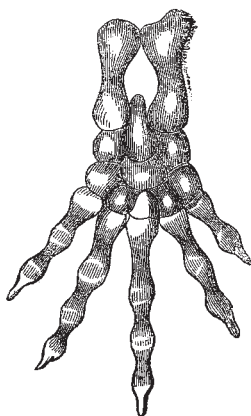


FIG. 53.

FIG. 53.—Skeleton of posterior extremity of an eft.
FIG. 54.—Bones of foot of Frog.—*a*, astragalus; *c*, os calcis; *ac*, united portions of these bones; *cb*, ossicle representing cuboid and other tarsal bones—*1, 2, 3, 4, 5*—the five metatarsals.

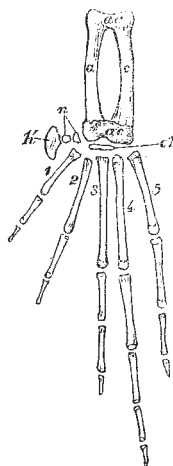


FIG. 54.

similar in form in animals remote enough from Batrachians, yet rarely do we find such in any intermediate kinds. Thus in certain tree-porcupines the ankle is furnished in like manner—another instance of the independent origin of strikingly similar structures.

* Continued from p. 150.

There are other matters, however, more important than this. It has been remarked that the wrist shows an



FIG. 55.—The Maholi Galago.

amount of resemblance to the same part in beasts which

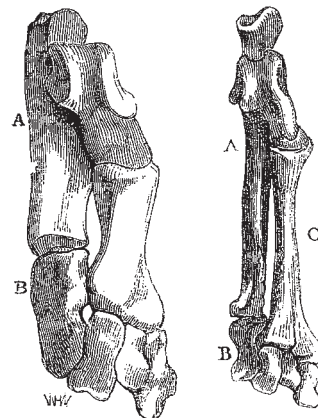


FIG. 56.—Elongated tarsus of Lemuroids. Left-hand figure, tarsus of *Cheirogaleus*; right-hand figure, tarsus of *Tarsius*. *A*, calcaneum; *B*, cuboides; *C*, naviculare.

is wanting in most reptiles and in all birds. The same

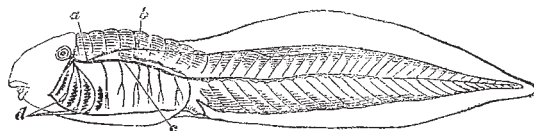


FIG. 57.—Tadpole of Bull Frog, partly dissected, to show the muscles of the tail and the branches of the 8th nerve or the vagus. *a*, great lateral branch giving off—*b*, a dorsal branch, and *c*, the lateral branch (or *nervus lateralis*); *d*, branches descending and passing along the branchial arches. The descending branches seen behind the branchial nerves on the side of the belly are not branches of the vagus at all, but spinal nerves, which come out from beneath the muscles and pass down under the *nervus lateralis*, and without having any communication with it.

observation may be repeated with far greater force as regards the ankle.

In all beasts, as in man, the motion of the leg on the foot takes place by means of a joint between the shin-bone of the leg and the small bones of the ankle; and though in some beasts (as in the orang) there is considerable power of motion between the first and the second row of ankle bones; this is small compared with the mobility of the foot and ankle taken together, upon the leg.

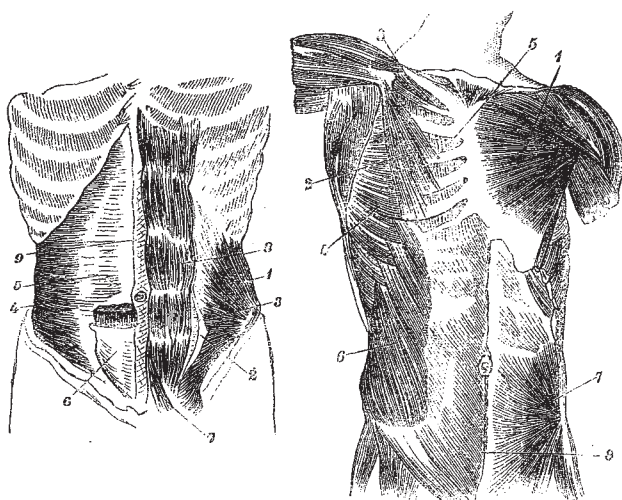


FIG. 58.

FIG. 59.

FIG. 58.—Anterior muscles of the Trunk: the pectoralis major of the right side and the left external oblique being removed. 1, pectoralis major; 2, pectoralis minor; 3, subclavius; 4, serratus magnus; 5, internal intercostals; 6, external oblique; 7, internal oblique; 8, linea alba.

FIG. 59.—Deeper Abdominal Muscles—the external oblique being removed from the left side of the body, and the internal oblique and part of the rectus also, from its right side. 1, the internal oblique; its outer tendon (2) is cut and reflected from the outside of the rectus to show its deeper tendon (3), which passes within the rectus except towards the pubis; 4, transversalis; 5, its fasciculus; 6, sheath of the rectus—near the pubis, the conjoined aponeuroses of the abdominal muscles pass in front of that muscle; 7, pyramidalis; 8, rectus of left side, showing the tendinous intervals, or *lineae transversae*.

In all birds, on the contrary, not only is there no motion between the ankle-bones (as a whole) and the shin-bone, but the two rows of ankle-bones actually ankylose respectively with adjacent parts—the row nearer the leg coming to form one with the shin-bone; the second row coming to form one with the bones of the foot. Thus in birds the motion of the foot on the leg takes place not

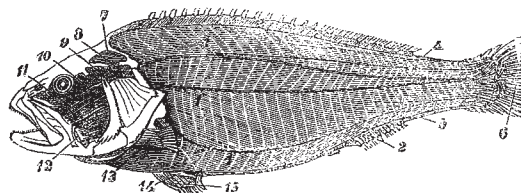


FIG. 60.—Superficial Muscles of the Perch. The fin-rays of all the fins are cut off. 1, great lateral muscle, showing the numerous vertical tendinous intersections slightly but variously inflected; 2, small superficial muscles inserted into the fin-rays of the dorsal and ventral fins; slender longitudinal muscle running (in the interval of the summits of the two great lateral muscles) between the dorsal and caudal fins; 3, similar muscle on the ventral margin, which also appears between the anal and ventral fins; 4, small radiating muscles of the caudal fin; 5, part of the great lateral muscle inserted into the skull; 6 and 7, elevators of the operculum; 8, elevator of the palato-quadrate arch; 9 and 10, muscular mass by which its contraction closes the jaws; 11 and 12, muscular mass by which its contraction closes the jaws; 13, superficial muscles of the pectoral fin; 14 and 15, muscles of the ventral fin.

between the ankle and the shin-bone but between the two rows of ankle-bones.

The same thing to a less degree takes place in reptiles; the ankle-bones do not indeed *ankylose* with the shin-bone and foot respectively, but they nevertheless unite with those parts so firmly that motion takes place between

the bones of the ankle and not between the whole ankle and the leg.

Now in the frog's class, e.g. in the order *Urodela*, we meet with a condition which is mammalian rather than reptilian or avian. Motion takes place freely between the leg and the whole tarsus. Moreover, the number and proportions of the ankle-bones themselves far more closely agree with the condition of the same parts exhi-

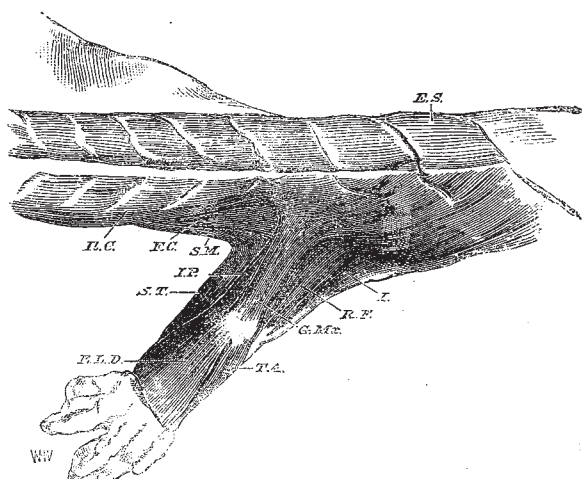


FIG. 61.—Superficial Muscles of Extensor Side of Leg and of parts of Trunk and Tail of Menopoma. ES, erector spinae—directly continued into dorsal half of tail; ELD, extensor longus digitorum pedis; FC, femoro-caudal; GMx, probably rectus femoris; I, muscle resembling iliacus; LLC, ilio-caudal; IP, ilio-peroneal; RF, part of great extensor of thigh; SM and ST, muscles like the semi-membranosus and semi-tendinosus.

bited to us by certain beasts than it does with that which is possessed by any bird or of most reptiles.

The frogs and toads, however, differ from the *Urodela* and present us with a peculiar condition of the ankle-bones, in that the two which represent the bones of the first row are so greatly elongated as to give to the limb an additional segment—as it were two “long bones” more.

We should search in vain through every other order of the Batrachian class, through every known group of birds and reptiles, both living or fossil, to find any analogous structure. None of the lowest mammals, no marsupial, no rodent, no insectivorous or carnivorous beast, no hoofed mammal, presents us with anything of the kind. Nevertheless, at almost the other end of the series, in the very

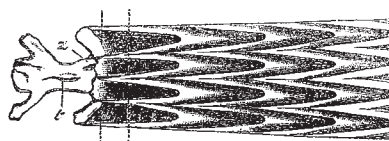


FIG. 62.—Diagram of Caudal Muscles of Right Side of Tail of Iguana, showing how the ventral mass resembles the dorsal part, and how the tendinous intersections of the muscular fibres are drawn out into cones. N, neural spine; H, hypapophyseal spine; z, zygapophysis; t, transverse process; 1, dorsal series of cones; 2, upper lateral series of cones; 3, lower series of cones; ventral series of cones.

highest order, that to which man himself belongs, we actually find a very similar development.

Amongst the very peculiar beasts which inhabit the island of Madagascar, there are certain small creatures, “Half-Apes,” belonging to the genus *Cheirogaleus*, in which two of the ankle-bones are elongated in a manner similar to that of the frog. The same character is more marked in an African genus of half-apes (*Galago*), and still more so in a third half-ape (*Tarsius*), from the island of Banca. Now it is absolutely impossible to believe that a special genetic affinity connects together by a peculiarly

common descent, Half-Apes and Frogs! We are then driven to the conclusion that we have here again a striking similarity of structure in two instances which are quite independent in their origin.

That the power of rapid and prolonged "jumping" does not carry with it as a necessary consequence the elongation of ankle-bones, is demonstrated by the fact that in other animals which, to say the very least, jump no less than do these half-apes—as for example in the kangaroos, jumping shrews, and jerboas—it is not bones of the ankle but bones of the foot proper, which take on an augmentation in length.

The Muscles of the Frog

We may now pass to the consideration of some points exhibited by another set of structures—namely, the muscles.

The muscles of an animal constitute its flesh, which as the most ordinary inspection shows us, is composed of different portions of soft fibrous substance separated from one another by interposed layers of membrane. Each such portion, so separated, is a muscle, and is attached at its two ends to two parts (bones or what not), which may be adjacent or more or less distant. The fibres which compose it have the remarkable property of contracting under certain conditions, and, when contracted, the whole muscle is shorter and thicker than before, and the two parts to which it is attached become consequently approximated.

Muscles may be large expanded sheets of flesh (as in the abdomen) or long and more or less narrow, as in the limbs.

Muscles are said to be "inserted," or to "take origin from" the parts to which they are attached, and they may be so inserted either by their own muscular fibres or by the intervention of a tough membrane or a dense fibrous cord called a "tendon."

All the motions of an animal are produced by means of the contractions of its muscles pulling the bones, which act as so many levers (of different kinds according to circumstances), and so effecting locomotion.

These muscular contractions are in life produced by the agency of certain of the nerves proceeding from the nervous centres, *i.e.* from the brain and spinal marrow, and which carry an influence outwards to the muscles. Other of the nerves so proceeding convey an influence inwards to the nervous centres from an irritated portion of the body's surface.

The muscles, however, especially in the frog may, for a time, be made to contract after death by direct irritation of the nerves themselves.

After the skeleton, it is the muscular formation of the body which mainly determines its general form and aspect, though occasionally—and often in the Frog's order—the voluntary inflation of the lungs will alone produce a vast modification in an animal's appearance.

The curious and grotesque resemblance which exists between the figure of the adult frog and that of man has been a common subject of remark. It may then be less surprising to some to learn that there is a great degree of resemblance between the muscles of the Rational and of the Batrachian animals; though the much greater gulf which separates the Batrachian than the Reptilian class from mammals may lead others to anticipate a greater divergence than in fact exists.

The frog, however, in its immature stage of existence, is widely different from the adult in its muscular (or myological) furniture, and this from one obvious reason.

"Muscles" are, as we have shown, *par excellence*, "organs of motion," and the motions of the tadpole are essentially different from those of the frog.

The frog, as all know, progresses on land by jumps, and swims through the water by a series of movements

which are in fact aquatic jumps. This action is familiar to many of us, not only from observation but also by imitation (the frog being a swimming-master given us by nature), but it is none the less a mode of swimming which is very exceptional indeed.

The tadpole progresses through the water in a very different manner, namely, by lateral undulations of its tail, which is the usual mode of swimming among vertebrate animals—that made use of by sharks and porpoises, as well as by the overwhelming majority of fishes.

Studying the life-history of this one animal, then, we become acquainted with a process of direct transition from the condition of a fish to that of a quadruped, as regards a most important group of organs.

In ourselves, the back is provided with muscles which extend along its length in a complex series of longitudinal divisions, from the middle line outwards.

The abdomen of man is inclosed and protected by successive muscular layers laid one upon another, the fibres of the successive muscles being differently directed. Thus we have (1) the external oblique (the fibres of which pass obliquely downwards and backwards, (2) the internal oblique (the fibres of which pass obliquely downwards and forwards), (3) the *Transversalis* (with transverse fibres), and (4) the *Rectus abdominus* (situated in the middle line of the body, and with fibres directed antero-posteriorly).

In the frog we also meet with the vast sheets of muscle with oppositely directed fibres (the external and internal oblique) and with a median, antero-posteriorly directed rectus muscle.

A very different condition exists in fishes, where there is indeed a median antero-posteriorly directed rectus, but where the abdomen and tail are encased with a mass of muscular fibres not arranged in superimposed sheets, but as a series of narrow segments separated from each other by layers of membrane. The edges of these membranous layers, when the skin is removed, appear as a successive series of undulating lines proceeding from the back to the belly.

Now the tadpole exhibits a muscular condition (Fig. 56) quite similar to that of the fish, and in the great persistent larva the axolotl, we find no truly oblique abdominal muscles, but only as it were a hypertrophied rectus.

In other species of the frog's class which retains a tail throughout life, the marked superimposed lamellæ are distinctly developed, but more or less distinct traces are also retained of the successive membranous partitions separating the muscular segments of both the dorsal and ventral regions.

Another stage of development may be detected in the tail-muscles of certain reptiles.

Here the membranous partitions have become drawn at short intervals from above downwards out into a formal shaped condition, so that the muscular fibres enclosed, assume the forms of cones. Moreover, the apices of the membranes enclosing the cones, become denser in substance, and so modified into ligaments.

We come thus to have a key to the process of development, by which the muscles of the back may be conceived to have arisen.

The muscles of the back may be conceived as having arisen through increasing obliquity, conical prolongation, and partial detachment (from muscle) of the separating membranous lamellæ; the produced ends becoming condensed with firm tendons directed more or less obliquely forwards.

The muscles of the abdomen may be conceived as having arisen through atrophy, in that region, of the separating membranes and subsequent splitting up of the muscular mass into super-imposed sheets of differently directed fibres.

This filiation between piscine and mammalian myology could hardly have been detected but for the remarkable series of gradations which the frog's class exhibits—

gradations both between species, and between different ages and conditions of one and the same species.

ST. GEORGE MIVART

(To be continued.)

BEES VISITING FLOWERS

ON the cliffs at Llwyngwrl, near Barmouth, *Lathyrus sylvestris* grows in large patches, and is freely visited by humble-bees. Where a plant grows in considerable masses, a great number of bees are naturally attracted, and the competition among them becomes severe. In this case the flowers are not sucked in the usual manner, but the bees bite holes through the corolla, and obtain in this way illegitimate access to the honey. Hermann Müller has shown that when flowers grow in any quantity, they are so diligently worked at by the bees that only comparatively a few contain any nectar; it is therefore important for the bees to find out as quickly as possible whether a flower is worth anything or not. These holes, bitten through the corolla, enable the bees to visit the flowers more quickly, and are thus a great saving of time. He also says that, although the bee which first gnaws the hole loses time in doing so, yet the advantage of being able to get the honey from the young and as yet unvisited flowers, fully makes up for the loss of time.

In *L. sylvestris*, as in many Leguminosæ, the honey is secreted within a nectary formed by the filaments of nine of the stamens soldered together. The trough-like cavity thus formed is covered in above and converted into a tube, by the tenth stamen. But at the base, where the trough enlarges into a bulb, the stamen is not wide enough to cover it, so that it leaves a pair of holes piercing the tube one on each side. It is through these "nectar-holes," as they are called, that the bee, after passing its proboscis down the tube of the corolla, or, as in the case already mentioned, through the holes bitten at its base, gains entrance to the staminal tube, in its search for nectar.

In *L. sylvestris* the hole is gnawed through the tube of the vexillum, close to the edge of the calyx, and exactly over the left nectar-hole. (Throughout this paper I mean the right and left of an observer looking at the front of the flower.) I think the reason of this constant choice of the left side of the corolla is that the left nectar-hole is usually somewhat larger than the right. I found this to be the case in sixteen out of twenty-four specimens of the wild *L. sylvestris*, and in eleven out of sixteen in the garden variety (the Everlasting Pea). It is difficult to say how the bees have acquired this habit. Whether they have discovered the inequality in the size of the nectar-holes in sucking the flowers in the proper way, and have then utilised this knowledge in determining where to gnaw the hole; or whether they have found out the best situation by biting through the vexillum at various points, and have afterwards remembered its situation in visiting other flowers. But in either case they show a remarkable power of making use of what they have learnt by experience.

The united filaments not only form the nectary, but also a sort of casing in which the ovary is enclosed; and out of which the growing pod has to break its way as it increases in size. In *Vicia cracca* it does so by lifting up the tenth stamen, but in most *Lathyri* the filament is too stiff to allow of such a movement, and the growing pod was to squeeze its way between it and the edge of the trough formed by the nine united filaments. In doing this it enlarges and at last splits open one of the nectar-holes. In *L. sylvestris* the left nectar-hole, usually the larger of the two as I have before said, is almost always the one which is thus opened. In *L. pratensis*, on the other hand, where the nectar-holes are equal, the pod

emerges indifferently to the right or left of the tenth stamen.

I am inclined to believe that the want of symmetry in the growth of the pod and the inequality in the size of the nectar-holes are in some way correlated, and that both are connected with a third asymmetrical character in the flower of this species. In most *Lathyri* the brush of hairs on the pistil is directed straight backwards towards the stalk of the flower. This is the case with *L. pratensis*, and also with the flower-buds of *L. sylvestris*, while very young; but, as they get older, the pistil rotates on its own axis, so that, in the adult flower, the brush is turned towards the left. I have often watched the bees sucking the flowers of the Everlasting Pea in the ordinary way, and have observed that the pistil, in consequence of being slightly bent as well as twisted on its own axis, emerges from the keel on the right side of the bee. The function of the brush is, as Mr. Farrer has shown (*NATURE*, vol. vi. p. 479, 1872), to sweep the pollen out of the keel, so that it may be transferred to the bees visiting the flower, and may be in this way subservient to the cross-fertilisation of the species. I believe that the twisting of the pistil helps to ensure this end, since in consequence of the brush being turned towards the left it rubs against the bee and smears it with pollen. Thus the mechanism for ensuring the cross-fertilisation of the plant is made more complete. At present the supposition that the asymmetrical character of the pistil is connected with the above described peculiarities and in the growth of the pod, is merely a conjecture.

These facts have a certain bearing on a peculiarity in the structure of the staminal tube in *Phaseolus multiflorus*, the Scarlet-runner. This flower, in common with many Leguminosæ, has a pair of nectar-holes at the base of its staminal tube; but the tenth stamen differs, as far as I know, from that of any other Leguminous plant, in possessing a little flap which projects from its upper surface just in front of the nectar-holes, and which almost completely blocks up the tube of the corolla. Mr. Farrer supposes (*loc. cit.* p. 480) that by pressing with its proboscis against this flap the bee levers up the tenth stamen, and in this way passes its trunk into the staminal tube. If this occurs at all, it must be like gnawing holes in the corolla, an illegitimate way of treating the flower, since it is impossible to believe that it should have well developed, but totally useless, nectar-holes. I believe the true function of this curious little flap to be as follows:—In many Papilionaceæ, *Lathyrus* for instance, the insect visiting the flower rests on a platform which is formed of the carina and the expanded alæ, but in the Scarlet-runner this platform is made up by the alæ alone, the carina being tightly coiled into a spiral close up to the entrance to the tube to the corolla. The alæ are attached, one on each side to the proximal part of the carina, so that when an insect rests on them, its weight bears on the carina, and causes the pistil which is contained in it as in a sheath to be forced out. The direction of movement of the pistil is downward and to the left, so that a bee resting on the expanded alæ and pushing in its head to the left of the coiled-up carina would come in contact with the pistil as it darted out of its sheath; but if the insect went to the right of the coil it would escape the pistil altogether. The end of the pistil is covered with hairs, and performs the same function as the brush in *Lathyrus* in smearing the bee with pollen. It is, therefore, of great importance for the cross-fertilisation of the plant that the bees should go to the left of the coil. As a matter of fact they all but invariably do go to the left; the very few bees that I have seen going to the right appear dissatisfied and unable to find their way into the corolla. Now to reach the nectar-holes the insect's proboscis has to pass down a tunnel formed above by the tube of the vexillum, below by the upper surface of the tenth stamen; the entrance into this tunnel is a narrow